A.D. 1867, *15th June.* N° 1755.

Electric Telegraphs.

LETTERS PATENT to Cornelius Varley, of 337, Kentish Town Road, in the County of Middlesex, and Samuel Alfred Varley, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEGRAPHS."

Sealed the 13th December 1867, and dated the 15th June 1867.

PROVISIONAL SPECIFICATION left by the said Cornelius Varley and Samuel Alfred Varley at the Office of the Commissioners of Patents, with their Petition, on the 15th June 1867.

We, CORNELIUS VARLEY, of 337, Kentish Town Road, in the County or Middlesex, and SAMUEL ALFRED VARLEY, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHS" to be as follows:—

Our Invention consists, 1stly, of an improvement in our method of generating electricity by mechanical force alone, or by mechanical force in combination with chemical action, for which we obtained Provisional Protection on the 24th day of December 1866, No. 3394.

2ndly, in an improved method of constructing galvanic batteries.

3rdly, in an improved arrangement of telegraph apparatus by means o which the number of wires used for signalling can in certain cases be reduced.

We construct our apparatus as follows:—We wrap soft iron bars with insulated wire in a similar way to an ordinary electro-magnet; these bars may be U-shaped and become electro-magnets when the apparatus is in use. We also construct bobbins with soft iron cores and warp them with insulated wire; these bobbins are of such a length that they will pass just freely between the poles of the electro-magnets. In constructing this apparatus two, four, or more electro-magnets may be employed; these electro-magnets are arranged opposite one another; the bobbins are mounted in pairs on an axle on opposite sides and when the axle revolves pass between the poles of the electro-magnets, and are so arranged that when one of the bobbins is between the poles of one of the electro-magnets the other bobbin is in the same relative position to the poles of the opposite electro-magnet; on the axle carrying the bobbins there is a commutator. The insulated wire surrounding the bobbins is connected to the commutator, and through it to the insulated wire of the electro-magnets, forming the whole into one electric circuit. Before using the apparatus we generally send an electric-current through the electro-magnets; the object of this is to secure a small amount of permanent magnetism in the direction we wish in the soft iron cores of the electro-magnets. On revolving the axle the bobbins become slightly magnetized in their passage between the poles of the permanent magnets, and as the electro-magnets are so arranged that the north pole of the one magnet is opposite the south pole of the other the bobbins are magnetized first in one direction and then in the other, generating weak currents (corresponding to the direction in which the bobbins are magnetized) in the insulated wire surrounding them. The commutator changes the connections of the electro-magnets at the same time as the magnetism of the bobbins is reversed, and consequently the electric currents developed in the bobbins always flow in one direction through the insulated wire of the electro-magnets. The effect of the current passing through the electro-magnets is to increase their magnetism and to magnetize in a higher degree the bobbins when passing between the poles of the electro-magnets; more powerful currents are now developed in the insulated wire surrounding the bobbins, which in their turn induce a higher degree of magnetism in the electro-magnets; in this way the magnetism developed in the electro-magnets and the bobbins act and react on one another, causing the circulation of increasing quantities of electricity. In constructing this apparatus to prolong the contact between the bobbins and the poles of the electro-magnets we generally arm the poles of the electro-magnets, or the bobbins with horns of soft iron. When we use four electro-magnets we employ two commutators and four bobbins; two of these bobbins and one commutator are arranged on the axle at right angles to the other bobbins and commutator, and the electro-magnets are wrapped with a double series of convolutions of silk or cotton covered wire insulated from one another. One set of the convolutions of insulated wire of the four pairs of electro-magnets is connected to one commutator, and the other set is connected to the other commutator. When we want currents of a definite amount of force for ringing electric bells, or for working other telegraph apparatus, we prefer to use permanent magnets, which we construct in the following manner:—We take a number of bar magnets and make a compound horse-shoe magnet by arranging two sets of them over one another. We connect the north poles of the one set with the south poles of the other at one end by means of plates of iron placed between the magnets, and we prevent the magnets from touching those beneath them at the other end by means of small pieces of iron of the same thickness as the plates connecting the north and south poles of the magnets at the other extremity; the bar magnets are now bolted together; a bobbin made of iron and wrapped with insulated wire is mounted on a lever and works between the poles of the compound magnet. On removing the bobbin from between the poles of the compound magnet a current is developed in the act of demagnetization. To prolong the duration of this current we construct two of these compound magnets, and arrange the north pole of the one opposite the south pole of the other; the iron bobbin now after passing from between the poles of the one magnet passes between the poles of the other, and a current of longer duration is generated. Instead of passing the bobbins between the poles as just described we sometimes arrange the two sets of compound magnets vertically, and we keep them at a fixed distance from one another by placing pieces of brass or other non-magnetic metal between. The surface of the upper poles of the magnets is filed so as to form a horizontal surface; a cylindrical soft iron keeper having a coil of insulated wire wrapped on the central portion is rolled over the poles of the one compound magnet on to the poles of ~~the~~ other, generating alternately positive and negative currents of electricity. In some cases we substitute a flat soft iron keeper for the cylindrical one, and when it is not desirable to move the coil of insulated wire we construct a bobbin with a hollow core; this bobbin is placed over the centre of the soft iron keeper, and the hollow core is made wide enough to allow the requisite motion of the keeper over the poles of the magnets; this method of generating electric currents is very suitable for actuating alphabetical telegraphs worked by any of the well-known step-by-step arrangements; when the magneto-electric machine just described is used for this purpose we mount a wheel, the periphery of which is usually cut into thirteen undulations or shallow teeth, on a vertical axle; a lever presses against this wheel and is moved backwards and forwards by revolving the wheel. The soft iron keeper is attached to the upper portion of this lever and the motion communicated to it by the revolution of the wheel causes the passage of the keeper over the poles of the magnets, generating for every whole revolution thirteen positive and thirteen negative currents, which currents are made to move a wheel of 26 teeth, one tooth at a time, by any of the well-known methods, and by means of an index to point out the letters of the alphabet. When we do not require very powerful currents of electricity we construct a horse-shoe electro-magnet, and mount it over the poles of a permanent horse-shoe magnet, leaving a space between; a disc of brass or other non-magnetic metal is mounted on an axle and revolves between the poles of the permanent and electro-magnets; a number of holes are bored through the brass disc and filled with pieces of soft iron. When the disc is revolved these pieces of iron pass between the poles of the permanent and electro-magnets making and breaking the magnetic continuity, and consequently developing positive and negative currents in the insulated wire of the electro-magnets.

In the ordinary method of constructing galvanic batteries a number of separate cells are employed, and each cell has to be charged separately. We construct our batteries of a series of cylinders or tubes open at both ends, the positive and negative elements are placed in these cylinders; the upper ends of these cylinders are attached to a frame by means of which they can be lifted in and out of a trough containing the exciting fluid. In the bottom of the trough we pour in a semi-fluid insulating cement obtained by submitting vulcanized or ordinary india-rubber to partial destructive distillation, so as to cover the bottom of the trough to a depth of about an inch, more or less. When the frame containing the cylinders is placed in the trough the lower ends of the cylinders become filled up with the semi-fluid cement before described, which possesses the property of adhering to substances under water and hermetically seals the cylinders, forming them into separate cells. By this method of constructing galvanic batteries twelve or more cells can be charged or re-charged with the same facility as one cell of the ordinary construction; other cements may be employed, but we prefer the cement above described. In certain cases of electric signalling one pole of a galvanic battery is connected through a galvanometer to an insulated wire, and the other pole of the battery to a metallic plate in connection with the earth, and the signals are made by connecting the insulated wire to the earth; when this method of signalling is adopted it is requisite to employ as many insulated wires as the number of signals desired.

By our improvement three signals can be obtained from two wires. We connect the two poles of a galvanic battery to the two insulated wires through two wires of a differential galvanometer and also through two relays the middle pair of elements of the galvanic battery is connected to the earth. Two signals can be given by connecting either the one or the other of the insulated wires to the earth. The third signal is obtained by connecting the two insulated wires together with a resistance between; when this is done galvanic currents flow through both wires of the differential galvanometer, but produce no deflection, as the galvanometer coils balance one another; the current at the same time passes through the two relays rendering them active; these relays are so arranged that when both are active a local circuit is closed through another galvanometer, deflecting a magnetic needle and giving the 3rd signal. If whilst the third signal is on either of the two insulated wires be connected to the earth the electric currents passing through the wires of the differential galvanometers will not balance one another, and consequently the needle of the galvanometer will be deflected in a direction corresponding to the wire connected to the earth.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Cornelius Varley and Samuel Alfred Varley in the Great Seal Patent Office on the 14th December 1867.

TO ALL TO WHOM THESE PRESENTS SHALL COME, we, Cornelius Varley, of 337, Kentish Town Road, in the County of Middlesex, and Samuel Alfred Varley, of 66, Roman Road, Holloway, in the said County of Middlesex, Telegraph Engineers and Contractors, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Fifteenth day of June, in the year of our Lord One thousand eight hundred and sixty-seven, in the thirtieth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto us, the said Cornelius Varley and Samuel Alfred Varley, Her special licence that we, the said Cornelius Varley and Samuel Alfred Varley, our executors, administrators, and assigns, or such others as we, the said Cornelius Varley and Samuel Alfred Varley, our executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improve-

MENTS IN ELECTRIC TELEGRAPHS," upon the condition (amongst others) that we, the said Cornelius Varley and Samuel Alfred Varley, our executors or administrators, by an instrument in writing under our, or one of our, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Samuel Alfred Varley, on behalf of myself and of the said Cornelius Varley, do hereby declare the nature of our said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our Invention consists, firstly, of an improvement in our method of generating electricity by mechanical force alone or by mechanical force in combination with chemical action, for which we obtained Provisional Protection on the 24th day of December 1866, No. 3394.

Secondly, in an improved method of constructing galvanic batteries.

Thirdly, in an improved arrangement of telegraph apparatus by means of which the number of wires used for signalling can in certain cases be reduced.

We construct our apparatus as follows:—We wrap soft iron bars with insulated wire in a similar way to an ordinary electro-magnet; these bars may be made U-shaped and become electro-magnets when the apparatus is in use. We also construct bobbins with soft iron cores, and wrap them with insulated wire; these bobbins are of such a length that they will pass just freely between the poles of the electro-magnets. In constructing this apparatus two, four, or more electro-magnets may be employed; these electro-magnets are arranged opposite one another. The bobbins are mounted in pairs on an axle on opposite sides, and when the axle revolves pass between the poles of the electro-magnets, and are so arranged that when one of the bobbins is between the poles of one of the electro-magnets the other bobbin is in the same relative position to the poles of the opposite electro-magnet. On the axle carrying the bobbins there is a commutator, the insulated wire surrounding the bobbins is connected to the commutator, and through it to the insulated wire of the electro-magnets, forming the whole into one electric circuit. Before using the apparatus we generally send an electric current through the electro-magnets; the object of this is to secure a small amount of permanent magnetism in the direction we wish in the soft iron cores of the electro-magnets. On revolving the axle the bobbins become slightly magnetized in their passage between the poles of the permanent magnets, and as the electro-magnets are so arranged that the north pole of the one magnet is opposite the south pole of the other the bobbins are magnetized first in one direction and then in the other, generating weak currents (corresponding to the direction in which the bobbins are magnetized) in the insulated wire surrounding them. The commutator changes the connections of the electro-magnets at the same time as the magnetism of the bobbins is reversed, and consequently the electric currents developed in the bobbins always flow in one direction through the insulated wire of the electro-magnets. The effect of the current passing through the electro-magnets is to increase their magnetism and to magnetize in a higher degree the bobbins when passing between the poles of the electro-magnets; more powerful currents are now developed in the insulated wire surrounding the bobbins, which in their turn induce a higher degree of magnetism in the electro-magnets. In this way the magnetism developed in the electro-magnets and the bobbins act and react on one another, causing the circulation of increasing quantities of electricity. In constructing the apparatus to prolong the contact between the bobbins and the poles of the electro-magnets we generally arm the poles of the electro-magnets or the bobbins with horns of soft iron. When we use four electro-magnets we employ two commutators and four bobbins; two of these bobbins and one commutator are arranged on the axle at right angles to the other bobbins and commutator, and the electro-magnets are wrapped with a double series of convolutions of silk or cotton covered wire insulated from one another. One set of the convolutions of insulated wire of the four pairs of electro-magnets is connected to one commutator, and the other set is connected to the other commutator. When we want currents of a definite amount of force for ringing electric bells or for working other telegraph apparatus we prefer to use permanent magnets, which we construct in the following manner:—We take a number of bar magnets and make a compound horse-shoe magnet by arranging two sets of them over one another; we connect the north poles of the one set with the south poles of the other set at one end by means of plates of iron placed between the magnets, and we prevent the magnets from touching those beneath them at the other end by means of small pieces of iron of the same thickness as the plates connecting the north and south poles of the magnets at the other extremity; the bar magnets are now bolted together; a bobbin made of iron and wrapped with insulated wire is mounted on a lever and works between the poles of the compound magnet. On removing the bobbin from between the poles of the compound magnet a current is developed in the act of demagnetization. To prolong the duration of this current we construct two of these compound magnets and arrange the north pole of the one opposite the south pole of the other; the iron bobbin now after passing from between the poles of the one magnet passes between the poles of the other, and a current of longer duration is generated. Instead of passing the bobbin between the poles as first described we sometimes arrange the two sets of compound magnets vertically (Figure 3), and we keep them at a fixed distance from one another by placing pieces of brass or other non-magnetic metal between. The surface of the upper poles of the magnets is filed so as to form a horizontal surface. A cylindrical soft iron keeper having a coil of insulated wire wrapped on the central portion is rolled over the poles of the one compound magnet on to the poles of the other, generating alternately positive and negative currents of electricity. In some cases we substitute a flat soft iron keeper for the cylindrical one, and when it is not desirable to move the coil of insulated wire we construct a bobbin with a hollow core; this bobbin is placed over the centre of the soft iron keeper, and the hollow core is made wide enough to allow the requisite motion of the keeper over the poles of the magnets. This method of generating electric currents is very suitable for actuating alphabetical telegraphs worked by any of the well-known step-by-step arrangements. When the magneto-electric machine just described is used for this purpose we mount a wheel, the periphery of which is usually cut into thirteen undulations or shallow teeth, on a vertical axle; a lever presses against this wheel and is moved backwards and forwards by revolving the wheel. The soft iron keeper is attached to the upper portion of this lever, and the motion communicated to it by the revolution of the wheel causes the passage of the keeper over the poles of the magnets, generating for every whole revolution thirteen positive and thirteen negative currents, which currents are made to move a wheel of 26 teeth, one tooth at a time, and by means of an index to point out the letters of the alphabet. This may be done by any of the well-known methods, but the plan we prefer is to construct a permanent tempered steel magnet the two poles of which meet at the centre and are curved so as to form portions of the radius of a circle, as shewn in Figure 6. A piece of soft iron is mounted on an axle and moves just freely between the poles of the permanent magnet and becomes magnetic by induction from the permanent magnet. An electro-magnet is mounted at right angles to the permanent magnet; the poles of this electro-magnet also meet in the centre, and are curved in a somewhat similar way to the poles of the permanent magnet, and form portions of the radius of a circle. The alternate positive and negative currents generated by the magneto-electric machine are made to pass through the electro-magnet, and the soft iron induced magnet becomes attracted and repelled in accordance with the direction of the electric currents passing through the electro-magnet. A driving escapement is mounted on the axle carrying the soft iron induced magnet, and this moves the wheel of twenty-six teeth, one tooth for every electric current generated. A permanent hard steel magnet may be substituted for the soft iron induced magnet. The vertical magnet may also be an electro-magnet, and the horizontal one a permanent magnet. When we do not require very powerful currents of electricity we construct an electro-magnet and mount it over the poles of a permanent magnet, leaving a space between the poles of the permanent and electro-magnets; in this space a disc of non-magnetic metal mounted on an axle revolves, a number of holes are bored through the disc and filled with pieces of soft iron; when the disc is revolved these pieces of iron pass between the poles of the permanent and electro-magnets, making and breaking the magnetic continuity in their passage, and consequently developing positive and negative currents of electricity in the insulated wire of the electro-magnet. Two permanent and two electro-magnets placed nearly at right angles to one another may be substituted in some cases with advantage for the one permanent and one electro-magnet, and be so arranged that the magnetic continuity may be completed through the one electro-magnet at the same time as it is being broken in the other.

In the ordinary method of constructing galvanic batteries a number of separate cells are employed, and each cell has to be charged separately. We construct our batteries of a series of cylinders or tubes open at both ends; the positive and negative elements are placed in these cylinders; the upper ends of these cylinders are attached to a frame, by means of which they can be lifted in and out of a trough containing the exciting fluid. In the bottom of the trough we pour in a semi-fluid insulating cement, obtained by submitting vulcanized or ordinary india-rubber to partial destructive distillation, so as to cover the bottom of the [trough to a depth of about an inch, more or less. When the frame containing the cylinders is placed in the trough the lower ends of the cylinders become filled up with the semi-fluid cement before described, which possesses the property of adhering to substances under water, and hermetically seals the cylinders, forming them into separate cells. By this method of constructing galvanic batteries twelve or more cells can be charged with the same facility as one cell of the ordinary construction. Other cements may be employed, but we prefer the cement above described. In certain cases of electric signalling one pole of a galvanic battery is connected through a galvanometer to an insulated wire, and the other pole of the battery to a metallic plate in connection with the earth, and the signals are made by connecting the insulated wire to the earth. When this method of signaling is adopted it is requisite to employ as many insulated wires as the number of signals desired.

By our improvements three signals can be obtained from two wires. We connect the two poles of a galvanic battery to the two insulated wires through two wires of a differential galvanometer, and also through two relays; the middle pair of elements of the galvanic battery is connected to the earth. Two signals can be given by connecting either the one or the other of the insulated wires to the earth. The third signal is obtained by connecting the two insulated wires together with a resistance between; when this is done galvanic currents flow through both wires of the differential galvanometer, but produce no deflection, as the galvanometer coils balance one another; the current at the same time passes through the two relays, rendering them active; these relays are so arranged that when both are active a local circuit is closed through another galvanometer deflecting a magnetic needle and giving the third signal. If whilst the third signal is on either of the two insulated wires be connected to the earth the electric currents passing through the wires of the differential galvanometers will not balance one another, and consequently the needle of the galvanometer will be deflected in a direction corresponding to the wire connected to the earth.

DESCRIPTION OF THE DRAWINGS.

The same letters refer to the same parts in each Figure.

Figs. 1 and 2 shew the construction of our machine for developing electricity by mechanical force. Figure 1 is a top view; Figure 2 is a side view with one half of the electro-magnets removed.

A, A, A^1, A^1; are the poles of two pairs of electro-magnets; B, B, B^1, B^1, are the soft iron horns attached to the electro-magnets to prolong the contact between the poles of the electro-magnets and the bobbins; C, C, are the bobbins; C^1, C^1, are the soft iron cores of the bobbins; E, E, is a brass box which holds the bobbins, and to which the axle F is attached by means of which the bobbins are revolved between the poles of the electro-magnets.

Figures 3, 4, 5, represent our apparatus for ringing electric bells, and shew our method of constructing compound permanent magnets for magneto-electric machines for actuating alphabetical telegraphs.

Figure 3 represents our apparatus for ringing bells, and shews our method of constructing the compound magnets. G, G, G^1, G^1, are four sets of magnetized tempered steel bars bolted together with plates of soft iron I, I, I, I, I, I, I, I, I, I, I, I, I, I, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, I^1, between, by means of the screw nuts and bolts H, H, H, H, H^1, H^1, and also to the iron block I; J, is a piece of brass, to which the upper portion of the magnets is bolted; K, K, K, are three of the four soft iron plates which connect the poles of the magnets and form a table, on which the soft iron core of the coils rolls or slides accordingly as it is made round or flat; L is the lever, by means of which the soft iron core is moved backwards and forwards from the poles of the one pair of magnets on to the poles of the other pair.

Figure 4 is a top view of the tooth wheel of 13 teeth and the apparatus connected therewith, which we employ for communicating motion to the lever L when the apparatus is used for actuating an alphabetical telegraph; Figure 5 is a side view of the same. M is the tooth wheel of 13 teeth; L is the lever, to the upper portion of which the soft iron core of the coil is attached in a similar way to that shewn in Figure 3; L^1 is a second lever, connected by means of the frame N and spiral springs O, O, to the lever L; P is the axle attached to the tooth wheel M, by means of which motion is communicated to it; Q, Q, are two rollers mounted on the levers L, L^1, as shewn in Figure 5, and kept in close contact with the tooth wheel on opposite sides by means of the spiral springs O, O; on revolving the tooth wheel by means of the axle P motion is communicated to the levers L, L^1, and the soft iron core of the coil moved backwards and forwards from the poles of the one pair of magnets on to the poles of the other.

Figure 6 shews the construction of the apparatus for actuating the wheel of 26 teeth, carrying the index which points out the letters of the alphabet. R, R, are the two poles of the permanent magnet, curved so as to form portions of the radius of a circle; S is the piece of soft iron mounted on the axle D, and working between the poles of the magnets, and which becomes magnetic by induction from the permanent magnet R, R; T, T, are the two poles of the electro-magnet, mounted horizontally, and which attract and repel the soft iron induced magnet. The driving escapement and wheel of 26 teeth are not shewn in the Drawing.

Figure 7 shews our method of constructing magneto-electric machines when we do not require very powerful currents of electricity generated. U, U, is a permanent magnet; V, V, is an electro-magnet; W is a disc of non-magnetic metal, mounted on the axle X, and which revolves between the poles of the electro and permanent magnets.

Figure 8 represents a top view of the disc W; Y, Y, Y, Y, Y, Y, Y, Y, Y, Y, Y, Y, are pieces of soft iron let into the disc W, and which complete the magnetic continuity in their passage between the poles of the permanent and electro magnets.

Having now stated the nature of our Invention, and described in what manner the same is to be performed, we wish it to be understood that what we claim is,—

First, the method of constructing the apparatus by means of which electricity may be generated by mechanical force, as shewn and described in reference to Figures 1 and 2.

Second, the method of constructing magneto-electric machines for ringing bells and actuating alphabetical telegraphs and apparatus connected therewith, as shewn and illustrated in reference to Figures 3, 4, 5, 6; and also the method of constructing magneto-electric machines, as shewn and described in reference to Figures 7 and 8.

In witness whereof I, the said Samuel Alfred Varley, on behalf of myself and the said Cornelius Varley, have hereunto set my hand and seal, this Fourteenth day of December, in the year of our Lord One thousand eight hundred and sixty-seven.

SAMUEL ALFRED VARLEY. (L.S.)

LONDON:
Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1867.

A.D.1867. June.15. No. 1755.
C.&S.A.VARLEY'S Specification.

(1 SHEET)

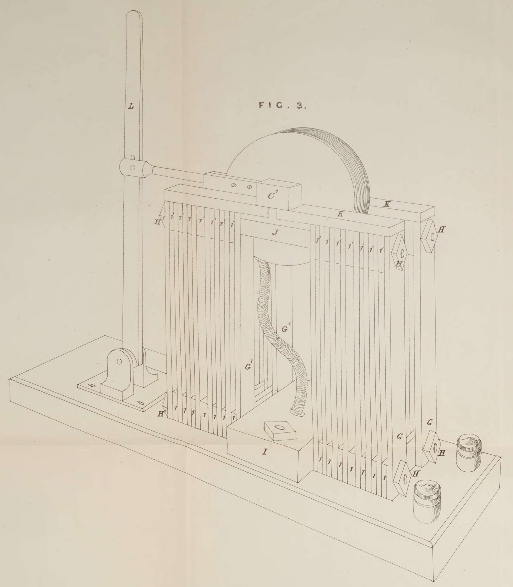


FIG. 3.

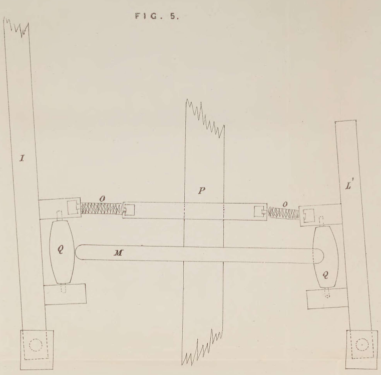


FIG. 5.

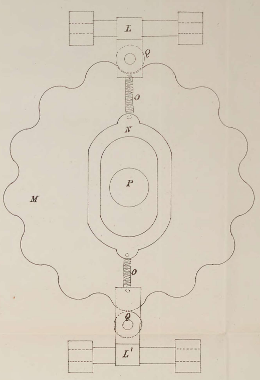
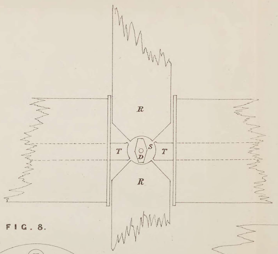


FIG. 4.



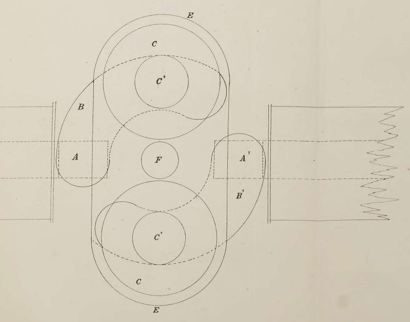


FIG. 2.

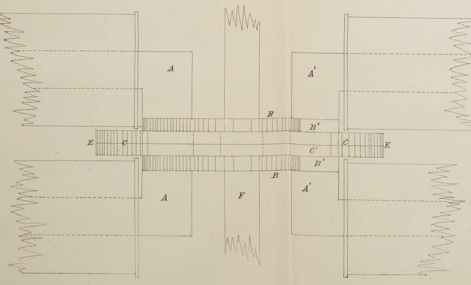


FIG. 1.

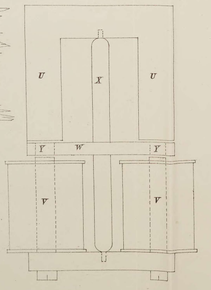


FIG. 7.

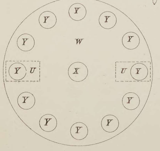


FIG. 8.

The filed drawing is partly colored.

Drawn on Stone by Malby & Sons.

London: Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1867